The Air Corps Advanced Flying School
Kelly Field, Texas

Maintenance

1927

SECTION II

THE DH-4B AIRPLANE

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13. Characteristics:- a. The original DH-4 airplane was designed during the year 1916 by Captain DeHaviland of the Royal Air Force. This plane was designed for reconnaissance flying at this time and was far superior to any two-seater bi-plane built previous to this date. Several types of engines were tried, among them being the 250-285 H.P. Rolls Royce, 200-220 H.P., R.A.F., 260 H.P. Fiat, and others. The Rolls Royce gave the best performance.

b. During the year 1917, the DH-9 was developed by the Royal Air Force, this being a modification of the DH-4. Later, this same year, experiments were made with the installation of the American built Liberty, 12 engine, which proved very successful and was immediately accepted by the American War Department, for use as a reconnaissance and observation plane.

c. The first model of this plane built by the American Government after its adoption was the DH-4A. This model, although having very good performance, was soon modified into what is known as the DH-4B type. The principal reason for the modification was the location of the main gasoline tank which was considered extremely hazardous to pilots in case of a crash.

d. Different Types: The DH-4B type with the Liberty 12 engine has been used extensively by the Army Air Service since 1918 for various purposes, principally advanced training, observation and reconnaissance. In some instances special installations have been made, depending on the mission for which it was to be used. These installations are designated as follows:

DH-4B	Standard Liberty 12 installation, 85 gal. main gasoline tank, 96 gal. total fuel capacity.
DH-4B1	Standard Liberty 12 installation, 110 gal. main gasoline tank, 118 gal. total fuel capacity.
DH-4B2	Standard Liberty 12 installation, 76 gal. leak-proof main gasoline tank, 83 gal. total fuel capacity.
DH-4B3	Standard Liberty 12 installation, 136 gal. main gasoline tank, 143 gal. total fuel capacity.
DH-4B4	Airways airplane with Liberty 12 installation prepared in accordance with Drawing #0104000.
DH-4BM1	Messenger type airplane, 135 gal. main gasoline tank, 143 gal. total fuel capacity.
DH-4BP1	Photographic airplane, Liberty 12 installation, adapted to vertical mapping, oblique and motion picture photography, in accordance with Drawing #X-39241.
DH-4BP3	Photographic airplane, Liberty 12 installation, adapted to vertical mapping, oblique and motion picture photography in accordance with Drawing No. X-47746, 110 gal. main gasoline tank, 118 gal. total fuel capacity.
DH-4M1	Liberty 12 installation, metal fuselage.

e. Dimensions: The following data was taken from a copy of an official report of a standard DH, equipped with a 400 H.P. Liberty Engine. (Report No. 2315):

Weight empty (including water)	2939 lbs.
Weight of armament and equipment	755 "
Weight of crew	360 "
Weight of gasoline (80 gal. at 5.91 lbs.)	473.5 lbs.
Weight of oil	67.5 "
Weight loaded	4595 "
Weight sq. ft. (440 area)	10.44 "
Weight - H.P. (416 H.P. at 1675 R.P.M.)	11.04 "
Overall span	41'5-15/32"
Overall length	29' 11"
Overall height	9' 8"
Wing Curve	R.A.F. 15

Sweepback - None
Dihedral -2-1/2 deg.
Stagger -12-1/2"
Total area (including ailerons) - - - - - - -440 sq. ft.
Gap -5'6"
Chord (upper and lower) - - - - - - - - - - -5'6"
Incidence (upper and lower) - - - - - - - - -3 deg.
Tread -6 ft.

f. Performance: With and without military load, equipped with propeller, Dwg. No. 37593, and 400 H.P. Liberty engine:

Gross weight - - - - - - - - - - - - - - - - 4050 lbs. *4595 lbs.
Absolute ceiling - - - - - - - - - - - - - -16900 ft. 14700 ft.
Service ceiling (R/C 100 ft./min.) - - - - 15325 ft. 12800 ft.

Rate of climb sea level - - - - - - - - - 1100 ft/min. 760 ft/m.
" " " 5,000 feet - - - - - - - - - 773 " " 505 "
" " " 10000 " - - - - - - - - - 446 " " 224 "

Time to 10,000 feet - - - - - - - - - - - 13.7 min. 22.1 min.
Time to service ceiling - - - - - - - - - 35.7 "

Speed in level flight sea level - - - - - -122.2 mph. 118 mph.
" " " " 5,000 ft. - - - - -117.0 " 115 "
" " " " 10,000 " - - - - -109.4 " 107.4 "
" " " " Service ceiling - - 94.5 " 97 "

R.P.M. in level flight sea level - - - -1705 1675
" " " " 5,000 ft. - - - -1665 1640
" " " " 10,000 " - - - -1610 1590
" " " " Service ceiling - -1510 1545

* All items of armament and equipment in place at time of test.

g. Detailed Description: The fuselage of the DH-4B is in two separable halves, each half being a complete unit. The front half is of veneer construction. The four spruce longerons are spaced by vertical and diagonal braces, the assembly being covered by flat sheets of plywood fastened by screws and glue. Practically all brace wires are eliminated, there being only a few to brace the engine bearers and to counteract the torsional stresses. The rear half is of stick and wire type construction, the brace wires being of swaged tie rods. The rear half is completely and independently aligned before being attached to the front half. The front half contains the engine and cockpit sections, while the rear half consistsoof only the tail section. The joint between the two halves is so arranged that they may be taken apart for shipping, or in case the rear half is damaged, a new tail section may be installed with the minimum amount of labor.

14. Assembly.- a. Each half of the fuselage is assembled separately. As there are no provisions for the adjustment of alignment of the front half after it is built, it must be built in perfect alignment. This is accomplished by means of jigs. The component parts of each side are assembled and clamped in position in a jig when the plywood sheets are fastened to all members by means of glue and screws.

b. The stations of the front half are numbered in rotation from the rear continuing from the stations of the rear half which are numbered from the rear, or tail post. The first three stations or "box" as it is called, of the rear half are built in position and alignment in the same manner, as the front half. The perfection of this portion must be determined by jigs or an alignment stand.

c. After the "box" portion of the rear half is completed, the remaining stations are assembled by inserting and connecting the proper struts and tie rods.

15. Shop Alignment.- a. A separate alignment stand for the rear half is advisable. If a complete fuselage is to be re-aligned, remove the rear half and correct its alignment in the same manner that a new rear half is to be aligned.

b. The rear half is aligned by making it square at each station and symetrical about the center line on all four sides.

c. The front half is placed in flying position on the alignment stand. The rear half is then placed in position with the ends of the longerons fitting snugly, then tested for overall alignment.

d. The upper longerons of the rear half must be at anlangle of $3\frac{1}{2}$ degrees and the center line of the rear half must coincide with the longitudinal center line for the entire fuselage. If necessary, the ends of the longerons of the rear half will be trimmed until condition is obtained.

e. If the longerons have been trimmed in fitting the rear half, it will be necessary to re-locate the bolt holes of the joint. This will be accomplished by plugging the old holes with snug fitting wood dowel pins, first coating the dowel and inside of the hole with glue. The fish plates are then placed in position and the bolt holes marked and bored.

f. When the tie rods at the joint are finally adjusted, they must not destroy the previously secured alignment of the two halves.

16. Hangar Alignment.- a. Frequently a fuselage will need a re-adjustment of alignment when no other form of repair will be necessary. This may be accomplished in the hangar without completely disassembling the airplane and sending the fuselage to the repair shop.

b. Remove the top engine cowling and rear deck cover and place the airplane in flying position. From this point, it will be necessary to determine whether the engine section or cockpit section has deviated from its original position.

c. After thus determining the base for the alignment, adjust the vertical brace wires of the tail section so that its upper longerons will be level laterally and decline toward the rear $3\frac{1}{2}$ degrees.

d. With the upper and lower horizontal brace wires, adjust each station to the center line.

e. If necessary, adjust the brace wires of the engine section to correspond to the corrected position of the balance of the fuselage.

17. Repair.- a. In practically all instances, repair will be limited to a replacement of defective parts. However, small cuts on landing gear struts can be repaired by splicing in a piece of wood, gluing and taping it in place. Members having more serious abrasions should be replaced. No attempt should be made to repair interplane struts or important fuselage members.

b. If it is necessary to replace panels of plywood, the old plywood will be removed carefully so as to prevent injuring the members inside. The old glue and fragments of plywood will be scraped from these exposed surfaces. The old panel, if sufficiently intact, may be used as a pattern for making the new panel, otherwise, the new piece must be cut to fit. The new screw holes should be bored about 1/2 inch from the glue as in the original manufacture.

c. During the repair, all radio banding will be restored and tested in accordance with Air Corps Specifications.

d. The repair of airfoils will be limited principally to the replacement of defective parts. In some few places, reinforcements may be added to a member that will be subjected only to compression. However, this method is not applicable to a member such as a capstrip, which is also subjected to tension stresses.

e. Splicing of spars will be at the discretion of the Engineering Officer.

f. In order to eliminate the use of wings and other surfaces which are not in a serviceable condition, the following is quoted from Technical Order No. 01-1-10:

(1) DH-4 wings which require replace of the following parts:

Front Spar - Rear Spar - More than 25% of Main Ribs.

(2) The following parts may be replaced or repaired, if the rest of the wing is in good condition:

All Capstrips - Leading Edge - Trailing Edge - Inner End Rib.

18. Recovering.- a. The covering of the front half of the fuselage consists of panels of plywood. This will be replaced as outlined before.

b. If the rear half is to be covered with fabric, it should be recovered as outlined in Air Corps Specifications. If it is desired to have the covering readily removable or opened for inspection or repair, side openings should be installed in the cover.

c. All metal fittings or other metal parts that will come in contact with the doped fabric should be first covered with a strip of tape, tacked in position.

d. If the rear half is to be covered with plywood, the skeleton framework must be perfectly aligned as outlined previously. The plywood panels may then be made from patterns or by measurement and applied with screws and glue as on the front half.

19. Wings.- a. The wings of the DH-4 are of the "stick" and "wire" type, externally braced. In this type of construction the essential features are the two spars; with ribs to transmit the air load to the spars; with drag bracing between the spars to take the drag stresses; and external bracing of struts and cables to take the lift load.

21. Inspection.- a. Inspection takes in rigging, controls and surfaces:

(1) Inspect for loose or torn covering.
(2) Inspect controls for looseness or slackness and frayed cables.
(3) Inspect rigging for frayed or loose wires; see that all turnbuckles are properly safetied and that fittings are intact.
(4) Inspect for loose or bowed struts. A loose or cracked strut or broken strut fitting can be usually determined by soundly shaking strut with the hand, and a bowed strut can easily be seen by sighting from the front of the ship.
(5) Inspect wheel and tail shocks for correct tension.

b. All wings and other surfaces on airplanes in use will be frequently inspected. Under average conditions, replacements or recovering will usually be necessary after 250 hours flying time. The conditions of service vary so much that it is impossible to definitely fix the number of hours. If inspection shows the covering or interior to be in an unsatisfactory condition, the covering will be removed, the frame work inspected, any necessary repairs will be made, and then given one coat of spar varnish, Air Service Specification No. 14,001. This inspection is primarily to determine the condition of the ribs, drift wires and fittings inside the wings, and not so much to determine the deterioration of the covering. Deterioration of the fabric, when properly covered with an opaque covering such as pigmented dope or pigmented varnish, is very slow, and will not take place unless the protective coating on the fabric has cracked and peeled.

c. If it is desired to install a new set of wings and place the original wings in storage, the old set of wings will be stored without covering, after slackening the wires and giving all metal parts a coat of approved rust preventative, War Department Specification No. 2-53. If no replacements are available, the frame will be covered, doped, finished, and marked, in accordance with Air Service Specifications Nos. 24,108, 100, and 24,105.

d. When wing frames, which have been stored uncovered, are needed for use, the rust preventative will be removed and they will be re-varnished, covered and finished as outlined above.

22. Rigging and Alignment.- a. Disassembly:
(1) Disconnect:

Nose drift wires at fuselage and coil up; aileron balance wire at center of leading edge of center section; aileron control cables at leading edge of each lower wing panel near fuselage; inner bay flying wires at fuselage and coil up; pitot tube at base of #3 strut and under lower right longeron. Remove nuts on wing hinge bolts (upper and lower) and cotter keys in clevis pins at lower ends of inner bay landing wire turn buckles and slack off about six turns on these turnbuckles. With two men supporting tips of a lower wing panel and a third man at front intermediate strut, a fourth on top of center section can withdraw upper wing bolts and then climb down and withdraw lower wing bolts. Men at tips of wings will now be able to raise tips sufficiently to permit withdrawal of clevis pins at lower ends of inner bay landing wire turnbuckles. Carry wing panels straight out, lower tip until wing skid supports weight, and then ease wing over onto leading wing edges where it may be completely disassembled. Numbers of wing struts run from right to left across entire ship, odd numbers in front; if numbered, assembly will be facilitated by remembering that front struts are 3/8" shorter than rear struts, and that outer struts are smaller in body than inner ones. Center section, empennage assembly and undercarriage assembly may now be completely removed, or nearly thrown out of alignment for re-rigging.

b. Assemble Landing Gear: Align landing gear by adjusting front and rear traverse brace wires so that corresponding pairs are of exactly the same length by steel tape measurement.

c. Align Center Section: Place fuselage in exact horizontal and lateral flying level by use of tail horse, axle blocking, and spirit level. Drop plumb lines from center holesoof all four upper wing hinges or clevises. By adjustment of center section front and rear bay wires align the center section so that horizontal measurement with steel tape from plumb lines to bottom longerons is exactly equal on opposite sides of fuselage. By adjusting stagger and anti-stagger wires in center section side bays, set stagger so that horizontal measurement with steel tape from plumb lines in center of bolt hole of lower hinge fittings is 12½" on each side of fuselage.

d. Assemble and Align Wing Panels: Assemble and align wing panels by inserting hinge bolts from top to bottom and connecting inner bay landing wires to their fittings. Have all flying wires and nose drift wires connected to their lower fittings but slack enough to sag slightly. By tightening turnbuckles at lower ends of outer bay front landing wires, at the same time taking up on corresponding turnbuckles of inner bay front landing wires so as to keep main spar true, make steel tape measurement from a point at base of #1 strut to a point at top of #5 strut exactly equal to the corresponding measurement from base of #11 strut to top of #7 strut. This will insure equal dihedral in each wing. Drive a small brad into leading edge of each upper wing panel exactly opposite vertical axis of numbers 1 and 11 struts, and stretch a string taut across these two brads. Now take up equally on turnbuckles on lower ends of outer front landing wires, keeping spars true by tensioning inner bay front landing wires, until vertical steel tape measurement from leading edge of center section to the dihedral string is 9-3/4". By tensioning lower nose drift wires make steel tape measurement from base of #1 strut to center of propeller hub nut exactly equal to corresponding measurement from base of #11 strut to center of propeller hub nut. By adjusting inner and outer bay stagger and anti-stagger wires, set stagger at struts numbers 1, 3, 8, and 11 equal to that at center section, or 12½". Now take up turnbuckles at bases of rear landing wires until 3 degree built-in angle of incidence at fuselage is carried out evenly to outer strut bolt. This can be done by sighting. Considerable care must be taken not to throw the stagger out, or to reset it correctly if so thrown out. Take up all flying wires and upper nose drift wires to tautness making upper drift wires equal in length. Recheck stagger and dihedral measurements. Allow a slight droop (about 1½ to 2 turns in the turnbuckles at base of outer rear landing wires), or wash in, to left wing and corresponding rise, or wash out, to right wing to counteract for torque and blast. Adjust aileron gap wires, and balance control cables, to center the stick in cockpit and carry alierons flush with trailing edges of wing panels.

e. Assemble and Align Empennage: Assemble empennage aerofoils, except rudder, and align both leading and trailing edges of horizontal stabilizer, by sighting against base of wing struts numbers 1 and 11. Align elevators, and last, rudder and vertical fin. The latter may be cocked slightly to left at front to decrease pressure on right end of rudder bar if desired. Make a final steel tape check of all corresponding overall measurements and see that all nuts, clevis pins, and turnbuckles are safetied. All bolts and clevis pins should be inserted from top or front, as case may be.

23. Rigging Notes.-

a. To Change Wheel:

- (1) Raise plane and block under landing gear strut so as to hold wheel, to be changed, off floor.
- (2) Remove cotter key, nut, and bolt from hub cap.
- (3) Remove wheel. If bushing is loose-fit in wheel, care should be taken to keep it clean if removed.
- (4) Replace wheel by reversed procedure.

b. To re-wind Shock Absorber:

- (1) Block under landing gear strut and remove wheel.
- (2) With proper length of shock absorber cord, put a loop on each end. To make loop, measure and mark a point 8 inches from the end of the unstretched shock absorber cord. Lay the end of the cord at the marked point and lash in place. Length of lashing should be about two inches. This will leave a loop of slightly lessthan a two inch opening.
- (3) Hook one loop on shock absorber frame and stretching the cord as much as one man can pull, wind it in successive loops around the shock absorber frame. Using 5/8" cord, approximately 10 complete turns can be put on. With these in place stretch end loop so as to hook it tightly on the frame.

(4) Fasten straps across top and bottom of shock absorber frame.

c. To change Landing Gear:

(1) Attach sling to engine in the same manner as used to remove engine. Engine is in this case bolted to bearers.
(2) Attach chain block to sling and raise until wheels clear floor by about four inches.
(3) Remove cotter keys, nuts, and bolts from upper landing gear strut fittings.
(4) Remove safety wire from turnbuckles of brace cables, and remove cables by disconnecting at turnbuckles.
(5) Remove chassis by removing upper ends of struts from the strut fittings on the fuselage.
(6) Place new chassis in position under the fuselage. Lower the airplane, at the same time guiding the upper ends of the struts into the strut fittings. Connect the brace cables and proceed in general by a process the reverse of that used in removing chassis.

d. To Assemble Center Section:

(1) Select proper struts and place in fittings on the fuselage. These struts will be numbers: 5, 6, 7, and 8: numbers 5 and 7 at the right and left front respectively, 6 and 8 at the right and left rear respectively.
(2) Raise center section into place, putting tops of struts in fittings on the center section of the wing.
(3) Attach stagger and bracing cables, and take up slack.
(4) Alignment of the center section is to be made before wings are attached.

e. To Assemble Wings:

(1) Place upper and lower wing panels in proper relative position with leading edges resting in "vee" blocks on the floor.

(2) Select struts and put in proper places between wing panels. Struts are numbered from front to rear, and from right to left. All odd numbered struts will, therefore, go between the front spar of the wing panels.

(3) Connect stagger cables and tighten sufficiently to hold struts in place.

(4) Connect flying and landing wires, take up slack.

(5) Put ailerons in place and insert hinge bolts. Put washers on hinge bolts and put cotter keys in place. Connect cables between ailerons and attach aileron control cables at aileron horns. Inspect aileron hinges and see that all cotter keys are in place.

f. To Mount Wings on Airplane:

(1) Raise wing cellule into place against fittings on the airplane. While holding wing cellule in place connect landing light wires and the tube to the air speed meter head on the right wing. Insert bolts from top down in wing fittings and attach landing and flying cables in inner bay.

(2) Connect aileron control cables.

g. To Mount Tail Surfaces:

(1) Put horizontal stabilizer in place and insert hinge-pins, front and rear. Insert cotter keys in hinge pins.

(2) Place vertical fin in position and bolt to tail post and to fittings in front of stabilizer.

(3) Attach brace cables and struts, taking up slack in cables.

(4) Place rudder in position, insert hinger pins. Place washers and cotter keys on hinge pins.

(5) Connect rudder control cables, at control horns.

(6) Put elevators in place and attach by hinge pins. Put washers and cotter keys on hinge pins.

(7) Attach elevator control cables at control horns.

h. To Adjust Controls:

(1) With control stick centered laterally, adjust aileron control cable so that there is one quarter inch droop of the trailing edge of each aileron below adjacent point on the trailing edge of wing.

(2) With control stick centered in fore and aft travel adjust elevator control cables so that the elevator is in a neutral position.

(3) With rudder bar perpendicular to longitudinal axis of the airplane, adjust rudder control cables to put rudder in neutral position.

(4) Care should be taken not to make control cables too taut.

SECTION III

SUMMARY OF MAXIMUM TOLERANCES

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